# APPLIED PHYSICS 1

# (CBCGS DEC 2016)

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### Q1](a) What are crystal imperfections? Mention any two significance of it. (3)

**Ans:-** *In an ideal crystal atoms or molecules are arranged in a regular and periodic manner. Any deviation in a crystal from a crystal from a perfect periodic structure is called IMPERFECTION. Real crystals are always imperfect in some respect as ideal crystal do not exist in nature and cannot even be produced artificially. Imperfections have some advantages as the resistivity, conductivity, colour, luminescence , mechanical and plastics properties of matter can be controlled by regulating imperfection. Point defects are localized defects which means that in the same crystal different types of points are observed at its different parts.*

*The crystal defects are classified into the following types:*

- *POINT DEFECTS which are zero dimensional defects.*
- *LINE DEFECTS which are one dimensional.*
- *SURFACE DEFECTS which are two dimensional defects and*
- *VOLUME DEFECTS which are two dimensional defects.*

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### Q1](b) Write schrodinger's time dependent and time independent wave equations of matter waves in one dimensional and state physical significance of these Equations (3)

**Ans:-** *1. ONE DIMENSIONAL TIME DEPENDENT SCHRODINGER EQUATION.*

$$\frac{-\hbar}{2m}\times\frac{\partial^2\Psi(x,t)}{\partial x^2} + V\Psi(x,t) = j\hbar\frac{\partial\Psi(x,t)}{\partial t}$$

*The first and second term on the left hand side represents the kinetic and potential energies respectively of the particles and the right hand side represents the total potential.*

*2. ONE DIMENSIONAL TIME INDEPENDENT SCHRODINGER EQUATION.*

$$-\frac{\hbar^2}{2m}\times\frac{d^2\Psi(x)}{dx^2} + V(x)\Psi(x) = E\Psi(x)$$

*3. THREE DIMENSIONAL TIME INDEPENDENT SCHRODINGER EQUATION*

$$H = -\frac{\hbar^2}{2m}\nabla^2 + V$$

*Schrodinger equation is the fundamental equation of quantum mechanics. This is extremely useful for investing various quantum mechanical problems. The wave function, the probability* *density, the energy values of a quantum mechanical particle, etc. in various situation can be calculated with the help of this equation.*

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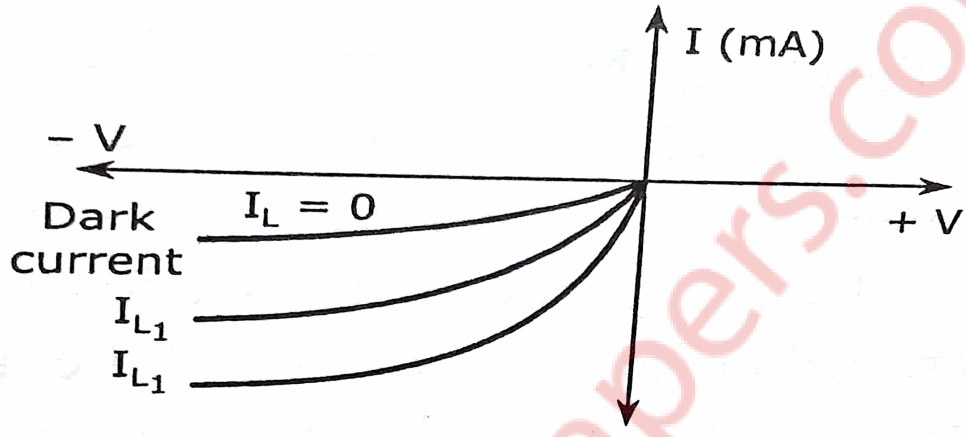
## *Q1] (c) Draw the I-V characteristics of a photo -diode. What is meant by dark current?* *(3)*

***Ans:-***




**(b)** I - V characteristic

*DARK CURRENT:*

***dark current*** *is the relatively small electric current that flows through photosensitive devices such as a photomultiplier tube, photo diode, or charge coupled device even when no photons are entering the device; it consists of the charges generated in the detector when no outside radiation is entering the detector. It is referred to as reverse bias leakage current in non-optical devices and is present in all diodes. Physically, dark current is due to the random generation of electrons and holes within the depletion region of the device.*

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## *Q1](d) Define super conductivity and critical temperature. Plot the variation of resistance versus temperature in case of superconducting state of the material.* *(3)*

***Ans:-*** *Superconductivity is a state of matter exhibited by some normal conductors when their resistivity suddenly drops to zero at a very low temperature. The superconductivity property of a material can be easily be effected by temperature , magnetic field and current.*

*Superconductivity is a property of some conductors the resistivity of which suddenly drops to zero at a certain low temperature ,* $T_c$*. These materials behave as superconductors below the critical temperature ,* $T_c$ *and as normal conductors .*

*The CRITICAL TEMPERATURE is the temperature at which the normal state of a conductor changes to superconducting state. critical temperature is different for different* *superconductors.*

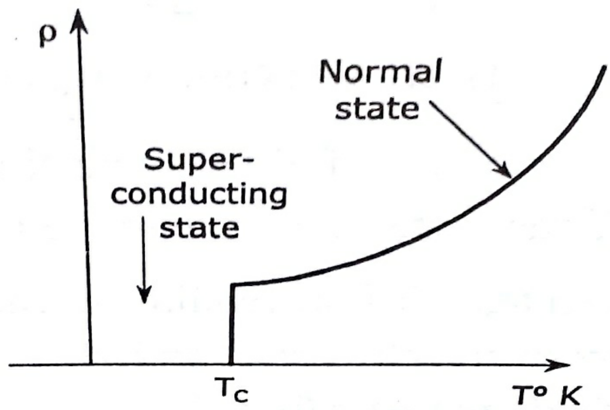


**Figure 4.2 : Resistivity of a Superconductor**

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## *Q1](e)What is reverberation time? Discuss sabine formula. (3)*

***Ans:-*** *The time taken by the sound to fall from its average intensity to inaudibility is called the reverberation time. It is also defined as time during which the sound intensity falls from its steady state value to its one-millionth value after the source is shut off*

$$\therefore \frac{I}{I_0} = 10^{-6}$$

*SABINES FORMULA.*

*Sabines derived an expression for the reverberation time of a furnished hall as follows.*

*The decay intensity is given by,*

$$I = I_0 e^{-KT}$$

$$\therefore \frac{I}{I_0} = 10^{-6}$$

*Hence,* $T = \frac{1}{K}\log_e \frac{I_0}{I} = \frac{2.303}{K}\log_{10}\frac{I_0}{I} = \frac{2.303}{k}\times 6$

*Hence reverberation time is given by* $T = 0.161 \times \frac{V}{A}$ *…………………………….(1)*

*Hence equation (1) is called as sabines formula.*

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## *Q1](f) State 'magnetostriction effect'. Mention any two application of ultrasonic waves. (3)*

***Ans:-*** *When a ferromagnetic rod is placed along a magnetic field it undergoes a small change in it length. If the steady magnetic field is replaced by an alternating magnetic field it undergoes alternate extension and contraction. If the frequency of the alternating magnetic field is high the* *rod starts vibrating exhibiting longitudinal vibrations. When the frequency of the applied field is high the rod produces ultrasonic waves in the surrounding medium.*

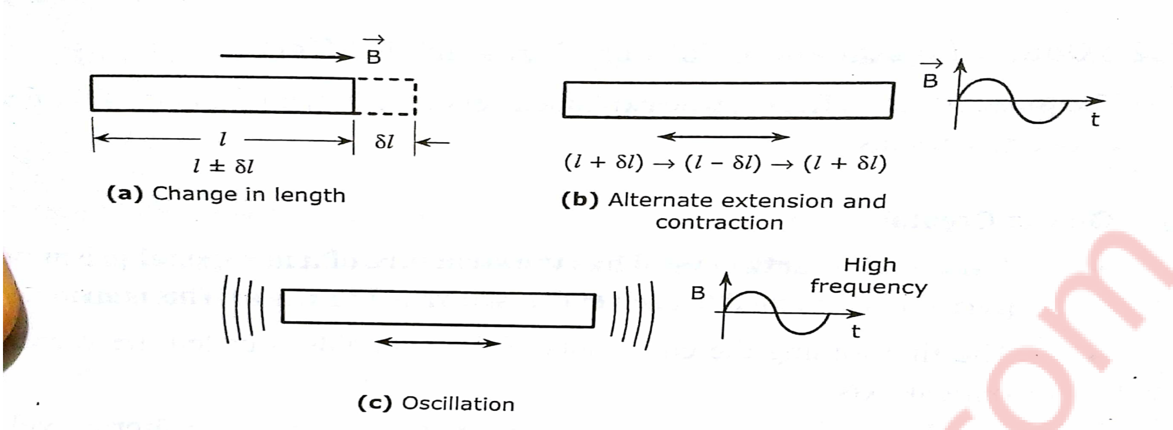


Figure 6.1 : Magnetostriction effect

*APPLICATION:*

- *Acoustic transducer : SONAR, Hydrophone, ultrasonic cleamimg, ultrasonic friction welding.*
- *Actuator: pump, Active valve, Rotary motor.*
- *Sensor: vibration sensor, position sensor, torque sensor.*

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***Q1](g) Calculate conductivity of a germanium sample if a donar impurity atoms are added to the extent to one part in $10^6$ germanium atoms at room temperature. Assume that only one electron of each atom takes part in conduction process.***

***Given:- Avogadro's number = 6.023 × $10^{23}$ atom/ gm- mol.***

***Atomic weight of Ge = 72.6***

***Mobility of electrons = 3800 $\frac{cm^2}{volts}$ sec***

***Density of Ge = 5.32 gm/ $cm^3$ .*** ***(3)***

***Ans:-*** *Given data :- N = 6.023 × $10^{23}$ atoms/ gm-mole , atomic weight of Ge, A = 72.6,*

$$\mu_e = 0.38\frac{m^2}{V}\text{-sec}, \qquad \rho = 5320\ kg/m^3$$

*Formula* :- $\sigma = n_e e \mu_e$

*Solution* :- *no .of atoms / unit volume =* $\frac{N\rho}{A} = \frac{6.023 \times 10^{26} \times 5320}{72.6}$

$= 441.35 \times 10^{26}$

No .of electrons added/ unit vol $= n_e = \frac{441.35\times10^{26}}{10^6}$

$= 441.35 \times 10^{20}$

Conductivity , $\sigma = n_e e \mu_e$

$= 441.35 \times 10^{20} \times 1.6 \times 10^{-19} \times 0.38$

$= 2683$

Conductivity = 2683 mho/ m.

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**Q2](a) Describe with the necessary theory the davisson and german establishing wave nature of electrons. Calculate the de-broglie wavelength of an alpha particle accelerating through a potential difference of 200 volts given:- mass of alpha particle = 6.68×$10^{-27}$ kg. (8)**

**Ans:-** *According to de Broglie's hypothesis, a beam of material particle must possess wave like characteristics and should undergo phenomena like reflection , refraction, interference, diffraction and polarization as the ordinary light waves do. The first experimental verification of wave nature of atomic particles was provided by davisson and germer.*

*DAVISSON-GERMER EXPERIMENT.*

*In this experiment , from a hot filament F electrons are accelerated by a small voltage V to strike a target made of a single nickel crystal.*

- *The electrons are scattered off the crystal in all directions.*
- *Help of an scattered electrons in all directions can be recorded with the help of an electron detector which can be rotated on a circular graduated scale.*
- *For any accelerating voltage ,V the scattering curve shows a peak or maximum in a particular direction. It is found that for an accelerating voltage of 54 volts a very large number of electrons are scattered at a particular angle , $\emptyset = 50°$.*
- *It is assumed that the electron undergoes diffraction and the peak represents the first order spectrum at an angle of $50°$.*

*The diffraction effects is explained as follows.*

- *The atomic planes of the nickel crystal act like the ruling of a diffraction grating.*
- *The interatomic distances of a nickel crystal is known to be a = 2.15 A°.*
- *The interatomic spacing of a nickel crystal is*

d = 0.09 A°.

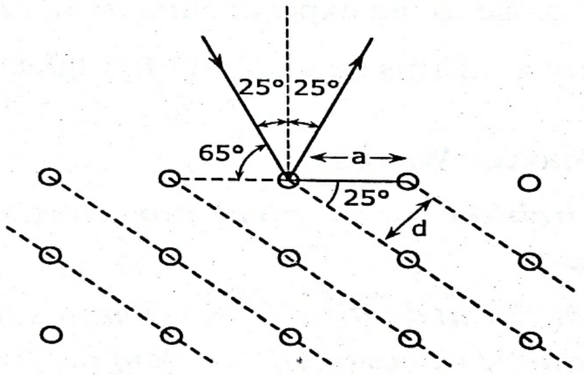



**Figure 2.2 : Electron diffraction by Nickel crystal**

- *Since, it is assumed that the electrons undergo diffraction they must follow braggs law,*

$$2d\sin\theta = n\lambda$$

- *It is seen that the glancing angle* $\theta = 65°$. *Assuming the order of diffraction , n= 1 the electron wavelength is experimentally calculated as*

$$\lambda_E = 1.65\ A°.$$

- *On the other hand since the electron energy is*

$$E = \frac{1}{2}mv^2 = eV$$

*The wavelength associated with an electron wave can be written as*

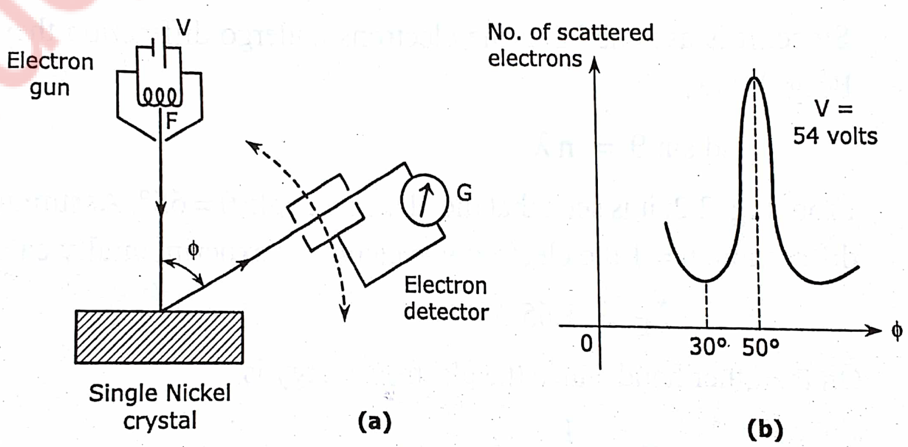
$$\lambda_T = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2meV}} = \frac{12.25}{\sqrt{V}}$$

- *here the accelerating potential V = 54 volts for which the theoretical electron wavelength is found to be*

$$\lambda_T = 1.67\ A°.$$

*Which is very close to the experimental value ,* $\lambda_E$.

- *This agreement confirms de Broglie hypothesis of matter waves.*



*NUMERICAL:*

*Given data :* - $m_p = 6.68 \times 10^{-27}$ *kg,* $q_\alpha = 4e = 6.4 \times 10^{-19} C$

*V = 200 volts.*

*Formula* :- $\frac{1}{2}mv^2 = q_\alpha V$ , $\lambda = \frac{h}{mv}$

*Solutions* :- - $\frac{1}{2}mv^2 = q_\alpha V$ , $v = \sqrt{\frac{2q_\alpha V}{m}}$

$$\lambda = \frac{h}{\sqrt{2q_\alpha mV}}$$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{2\times6.4\times10^{-19}\times6.68\times10^{-27}\times200}}$$

$$= 0.507$$

*Answer : de Broglie wavelength of an alpha particle*

$\lambda_\alpha$ *= 0.507 A°.*

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***Q2](b) Define the term drift current and mobility of a charge carriers. Calculate the current product in a germanium sample of area of cross section 1*** $cm^2$ ***and thickness of 0.01 m, when a potential difference of 2V is applied cross it. Given :- the concentration of free electron in germanium is*** $2\times10^{19}/m^3$ ***and mobilities of electrons and holes are 0.36*** $m^2$/volts ***sec and 0.17*** $m^2$/volts ***sec respectively.***

***(7)***

***Ans:-*** *DRIFT CURRENT :-*

*Drift current is the electric current caused by particles getting pulled by an electric field. Direction of the drift current is always in the direction of the electric field.*

*The amount of drift current depends on the concentration of charge carriers and their mobility in the material or medium.*

*MOBILITY OF CHARGE CARRIERS :-*

*This is a property of conductor, defined as the ratio of drift velocity to applied electric field in a conductor. Drift velocity of charge carriers in a conductor depend upon two factors, one is the intensity of applied electric field across the conductor and other is one property of the conductor called Mobility of Charge Carrier.*

*The SI unit of mobility is* $\frac{m^2}{V}sec$

NUMERICAL:

*Given data* :- $A = 1\text{cm}^2 = 10^{-4}\text{m}^2$, $t = 0.01m$, $V = 2$ volts.

$$n_i = 2\times10^{19}/\text{m}^3, \quad \mu_e = 0.36\frac{\text{m}^2}{\text{V}}\text{-sec}, \quad \mu_h = 0.17\frac{\text{m}^2}{\text{V}}\text{-sec}$$

*Formula* :- $\sigma = n_i(\mu_e + \mu_h)e$, $R = r\frac{t}{A}$, $V = IR$.

*Solution* :- $\sigma = n_i(\mu_e + \mu_h)e$

$$= 2\times 10^{19}(0.36+0.17)\times1.6\times10^{-19}$$

$$= 1.696 \text{ mho/m}$$

$$R = r\frac{t}{A} = \frac{1}{\sigma}\frac{t}{A}$$

$$= \frac{1}{1.696}\times\frac{0.01}{10^{-4}} = 58.96\,\Omega$$

$$I = \frac{V}{R} = \frac{2}{58.96} = 0.0339 \text{ Amp}$$

Current :- 0.0339 Amp.

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## Q3](a) Draw and explain the unit cell of sodium chloride (NaCl) crystal determine effective number of NaCl molecule per unit cell and co-ordination number. (8)

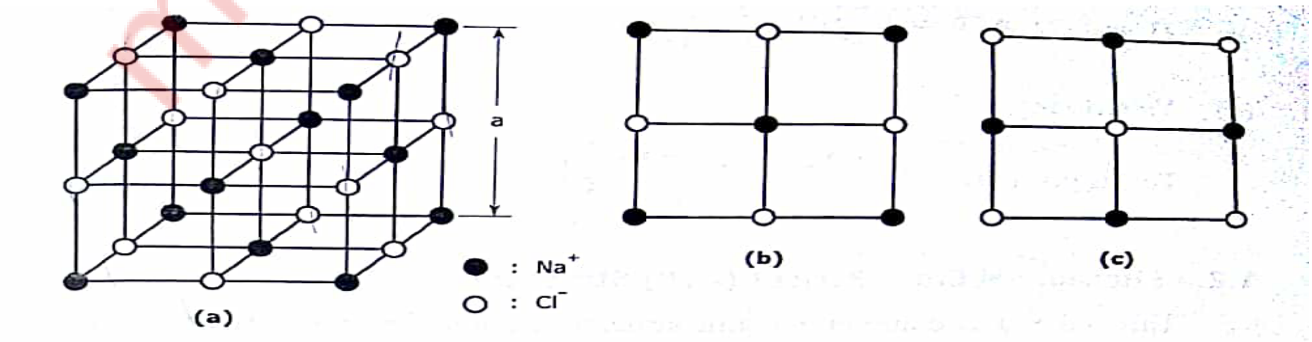
**Ans:-** NaCl STRUCTURE:-

*This is an ionic structure in which the $Na^+$ ions and $Cl^-$ ions are alternately arranged. It is a combination of two FCC sublattice one made up of $Na^+$ ions and the other of $Cl^-$ ions as if one sublattice is translated through the other along the cube edges.*

*NaCl unit cell with $Na^+$ ions occupying the regular FCC lattice points with $Cl^-$ ions positioned at alternate points. A face of this unit cell is shown.*

*Another NaCl unit cell can be considered with the positions of $Na^+$ and $Cl^-$ ions interchanged. The face of such a unit cell is shown.*

*NaCl UNIT CELL PARAMETER:*



*(a) Total number of molecule / unit cells*

*Calculation for* $Na^+$ *= Here* $Na^+$ *forms a FCC structure. Hence total number of* $Na^+$ *ions = 4*

*Calculation for* $Cl^-$ *= There are 12*$Cl^-$ *ions at the edges. Every edge lattice points is shared by four neighbouring unit cell. Hence every edge lattice point carries ¼ of an atom. There is one whole* $Cl^-$ *ion at the centre of the structure. Hence ,*

*Total number of* $Cl^-$ *ions =* $(12 \times \frac{1}{4}) + 1 = 4.$

*Since there are 4* $Na^+$ *ions and four* $Cl^-$ *ions in a NaCl unit cell , there are four NaCl molecule present in a unit cell.*

*Hence number of molecule / unit cell = 4.*

*(b) Atomic Radius (r)*

*Since NaCl is an ionic structure and cations are smaller than anions it is assumed that radius of cation =* $r_C$ *and the radius of an anion =* $r_A$.

*(c) Atomic packing factor(APF)*

$$APF = \frac{\left(4 \times \frac{4}{3}\pi r_C^3\right) \times \left(4 \times \frac{4}{3}\pi r_A^3\right)}{a^3}$$ *it is found that* $a = 2r_C + 2r_A$

*Hence,* $$APF = \left(\frac{2\pi}{3}\right)\frac{r_C^3 + r_A^3}{(rC+rA)^3}$$

*(d) Void space.*

*This is given by* $$\left[1- \left(\frac{2\pi}{3}\right)\frac{r_C^3 + r_A^3}{(rC+rA)^3}\right]$$

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***Q3](b) State application of Hall effect. In a Hall effect experiment a potential difference of 4.5*** $\mu V$ ***is developed across a foil of zinc of thickness 0.02mm when a current of 1.5 A is carrying in a direction perpendicular to applied magnetic field of 2 tesla. Calculate :-***

***(a)Hall coefficient for zinc.***

***(b)Concentration of electron.*** ***(7)***

***Ans:-*** *If a current carrying conductor or semiconductor is placed in a transverse magnetic field, a potential difference is developed across the specimen in a direction perpendicular to both the current that the magnetic field. The phenomenon is called as HALL EFFECT.*

*The net electric field E acting on the charge carriers is a constant of the applied electric field* $E_x$ *and hall electric field* $E_H$. *The angle made by E with the x axis is called the Hall angle which is given by:-*

$$\theta_H = \tan^{-1}\left(\frac{E_H}{E_X}\right)$$

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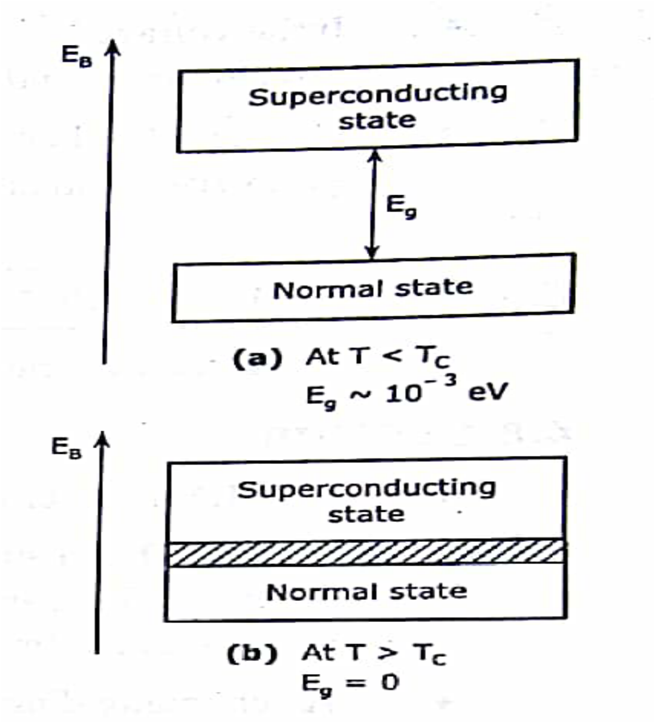
***Q4](a) Discuss formation of copper pairs and energy gap in superconductor on the basis of BCS theory.***
***(5)***

***Ans:-*** *The quantum theory of superconductivity developed by bardeen, cooper and schrieffer is known as BCS theory.*

- *During conduction the electron motion is interrupted by these phonon waves and resistivity aries in normal conductors.*
- *In superconductors during the interaction of electrons with phonons some electron absorbs phonons and their energy increases by an amount h$\vartheta$. When they release this energy as phonons other electron absorbs them. In this way electron in superconductors interact with each other through the emission and absorption of phonons.*
- *If a phonon emitted by one electron is absorbed by another electron, the electron form a pair called Cooper pair. This phonon mediated electron interaction is attractive.*
- *There exist an energy gap between the superconducting state and the normal state. this is different from the energy gap in band theory of solids. This energy gap represents the binding energy of a cooper pair. This is of the order of $10^{-3}$eV at low temperature .*
- *In the cooper pairs of electrons the spin and the momenta are correlated. Cooper pairs have a spin zero.*
- *The stability of copper pairs results in superconductivity.*

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***Q4](b) State any five factors affecting the acoustics of the building and give the remedies for each. (5)***

***Ans:-*** *The defects ,that commonly affect the acoustics of a hall and how to eliminate them to design a good auditorium are described as follows:-*

1. *Defect = NOISE*

*Any unwanted sound which can be created inside the hall or can be carried by air from outside into the hall is called noise.*

*Design = Proper site selection*

*A site with quite surrounding is proper for a hall or auditorium. The background noise level of the hall should be below 40-50 dB.*

2. *Defect = Echo*

*Echo is a sound wave reflected from a parallel hard smooth surface. Excessive echo affects the acoustics of the hall.*

*Design = A splayed floor plan and the covering of interior surface with suitable absorbent material minimize the defect and distribute the sound energy uniformly throughout the hall.*

3. *Defect = Echelon Effect*

*Successive echo of a sound from a set of regularly spaced parallel and smooth surfaces cause Echelon effect which makes the original sound unintelligible.*

*Design = the steps inside the hall should be covered with absorber like carpets.*

4. *Defect = Insufficient loudness*

*Excessive absorption and low reflection of the sound leads to this defect.*

*Design = in addition to loud speaker large sounding boards are used behind the source of sound. The absorbent materials are adjusted for this purpose, as well.*

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**Q4](c) An ultrasonic pulse of 0.09M Hz sends down towards the sea-bed which returns after 0.55 seconds. The velocity of ultrasonic waves in sea water is 1800 m/sec . calculate the depth of sea and wavelength of ultrasonic pulse. (5)**

**Ans:-** *Given data :- f =* $0.09 \times 10^6$ *Hz, t=0.55 sec , v=1800m/sec.*

*Formula :- 2d = vt , v = f*$\lambda$

*Solution :-* $d = \frac{vt}{2} = \frac{1800 \times 0.55}{2}$ *= 495 m*

$\lambda = \frac{v}{f} = \frac{1800}{0.09 \times 10^6}$ *= 0.2 A°*

*Answer :- depth of sea = 495 m*

*Wavelength = 0.2A°*

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**Q5](a) How does the position of fermi energy level changes with increasing doping concentration in p-type semi-conductor ? sketch diagram. (5)**

**Ans:-** *This type of break down occurs when a high reverse voltage is applied to a lightly doped junction diode as shown. In this case , the minority electron of the p side acquire high kinetic energy with which they knock out the valence electrons of the host atoms producing electron-hole pairs. These electron hole pairs gain kinetic energy from the electric field and in turn produce more and more electron pairs. This is called avalanche multiplication which occurs in a very short time to give large reverse current.*

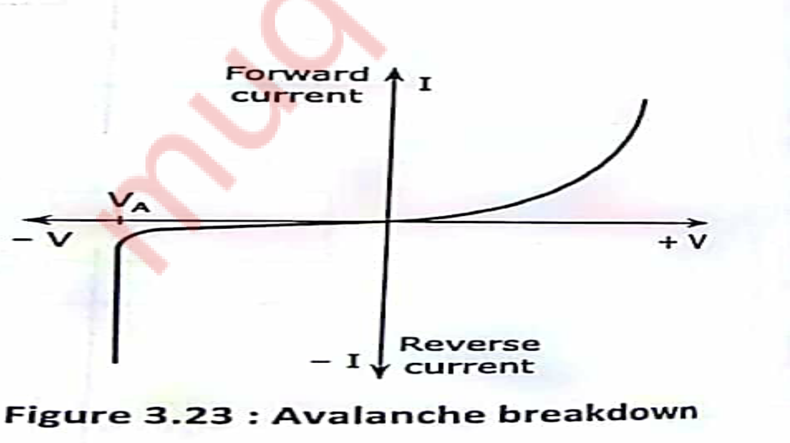


Figure 3.23 : Avalanche breakdown

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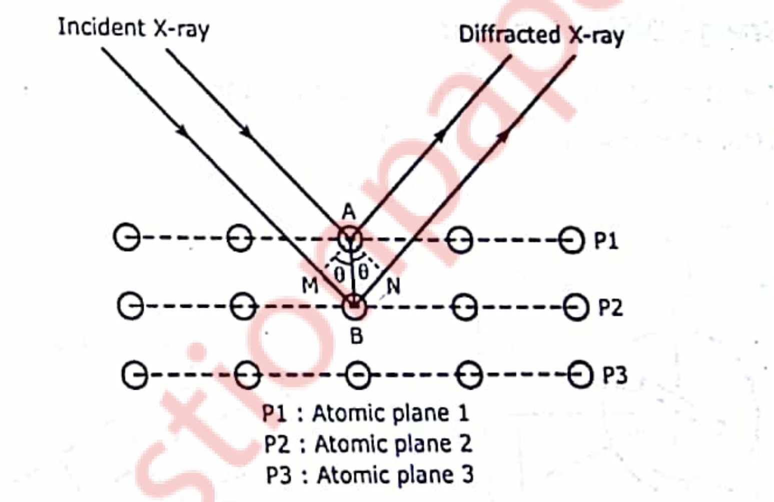
***Q5](b) Explain analysis of crystal structure using Bragg's X ray spectrometer (5)***

***Ans:-*** *W.L Bragg's explained the phenomenon of X-ray diffraction from a single crystal shown as follows*

*When a beam of X-rays is incident on a crystal it is scattered by individual atoms of the rich atomic planes. Thus, each atom become a source of scattered radiation. The atomic planes responsible for the X-ray diffraction are called BRAGG'S PLANES. Therefore the sets of Braggs planes constitute the crystal grating. Bragg's scattering or Bragg's diffraction is also referred as Braggs reflection. Bragg derived a law called Bragg's law to explain the X-ray diffraction effect.*

*Here a beam of X-ray is incident on a set of parallel planes of a crystal. The rays makes a glancing angle $\theta$ and are practically reflected from different successive planes. The phase relationship of the scattered rays can be determined from their path differences. Here two parallel X-rays are reflected from two consecutive planes PI and P2. The path differences between then as shown*




$$\delta = MB + BN = 2MB = 2AB\sin\theta$$

*Here AB = d, the interplanar spacing of the crystal. Hence,*

$$\delta = 2d\sin\theta$$

*The two diffracted rays reinforce each other when they interfere constructively when their path difference $\delta$ is equal to $n\lambda$*

*Hence,* $2d\sin\theta = n\lambda$

*This is called Bragg's law.*

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***Q5](c)Find the minimum energy of neutron confined to a nucleus of size of the order of $10^{-14}$m.***

***Given mass of neutron = $1.675\times10^{-27}$kg*** ***(5)***

**Ans:-** *Given data :- L =* $10^{-14}$m

*Formula :-* $E_n = n^2(\frac{h^2}{8mL^2})$ ……………………(n = 1,2,3…..)

*Solution :-* $E_n = n^2(\frac{h^2}{8mL^2}) = \frac{(6.63\times10^{-34})\times(6.63\times10^{-34})}{8\times1.67\times10^{-27}\times(10^{-14})^2}$ …..(n=1)

$E_1 = 3.29\times10^{-13}J$

*Lower energy =* $3.29\times10^{-13}J$

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**Q6](a) Calculate the critical radius ratio of an ionic crystal in ligancy-6 . what is the maximum size of cation in ligancy 6 configuration when size of anion is 2.02A° ?(5)**

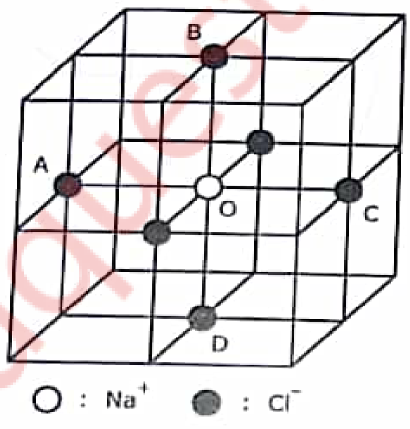
**Ans:-** OCTAHEDRAL CONFIGURATION:

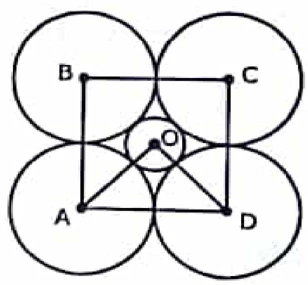
*The octahedral configuration of neighbouring anions is found in NaCl structure. Here four anions A, B ,C and D are arranged at the corners of a square with the cation O at the centre of the square. Two more anions are situated in front and at the back of the cation. The centres of all six anions form an octahedron.*

*Here in Δ BOC , < BOC = 90°, BC =* $2r_A$ *, OB =* $r_C + r_A$ *and <BCO =45°,*

*Hence,* $\frac{BO}{BC} = \cos45°$

*Or,* $\frac{r_C+r_A}{2r_A} = \frac{1}{\sqrt{2}}$




*The critical radius ratio here is,*

$$\frac{r_C}{r_A} = 0.414$$

*NUMERICAL:*

*Given data* :- $r_{A(max)} = 2.02A°$ , *ligancy = 6.*

*Formula* :- *for ligancy 6* ,$(\frac{r_C}{r_A})$ *= 0.732.*

*Calculations* :- $r_C = r_A \times 0.732 = 2.02 \times 0.732 = 1.478$ A°

*Answer* :- $\underline{r_c = 1.478A°}$

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***Q6](b) What do you mean by group and phase velocity? Show that the de-Broglie group velocity associated with the wave packet is equal to the velocity of the particle.*** ***(5)***

***Ans:-*** *GROUP VELOCITY:-*

*When a number of waves of slightly different wavelengths and velocities travel together in a medium the observed velocity of this group of waves is called the Group velocity. Such a group of waves is called a wave packet.*

*PHASE VELOCITY:-*

*The velocity with which a wave travels through a medium is known as phase velocity or wave velocity.*

*RELATION BETWEEN PHASE AND GROUP VELOCITY.*

*Consider a particle of rest mass* $m_o$ *moving with a velocity v, which is very large and comparable to c with v<c , its mass is given by the relativistic formula.*

$$m = \frac{m_o}{\sqrt{1-(\frac{v^2}{c^2})}}$$

$$\omega = 2\pi\vartheta \text{........( } \omega = \text{angular frequency )}$$

$$= 2\pi\left(\frac{E}{h}\right) = 2\pi(\frac{mc^2}{h})$$

*And* $$k = \frac{2\pi}{\lambda} = \frac{2p\pi}{h} = \frac{2\pi}{h}(mv)$$

*Wave velocity is the phase velocity given as*

$$V_p = \frac{\omega}{k} = \frac{c^2}{v}$$

$$V_p = \frac{d\omega}{dk}$$

$$V_g = \frac{d\omega/dv}{dk/dv}$$

$$V_g = V$$

*This shows that a matter particles in motion is equivalent to a packet moving with group velocity $V_g$ whereas the component waves moves with phase velocity $V_p$.*

*Hence the relation between phase velocity and group velocity is:-*

$$\therefore V_p V_g = c^2$$

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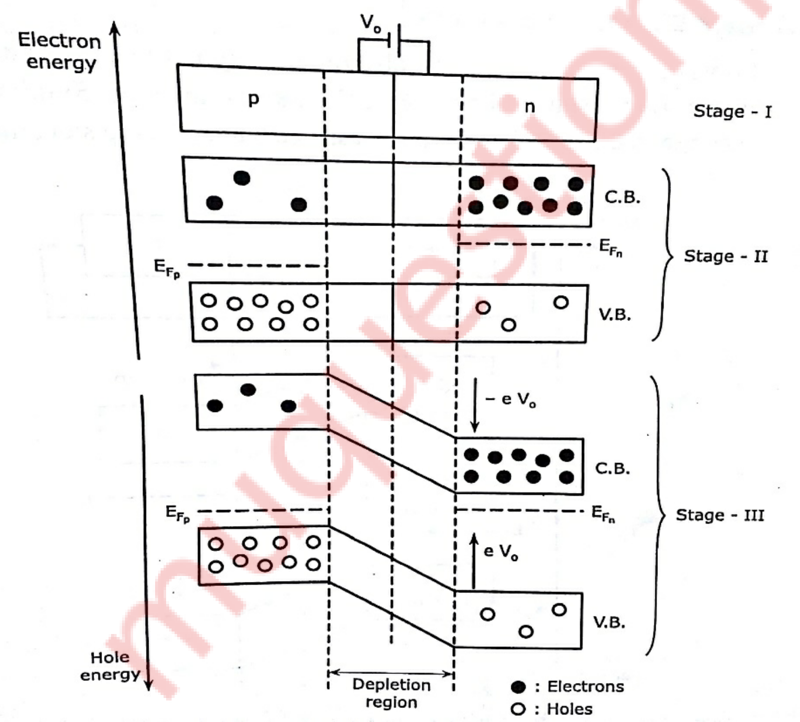
## *Q6](c)Explain the formation of potential barrier across the unbiased p-n junction region (5)*

***Ans:-*** *The p-n junction is formed at the initial stage , the fermi level on the p and n sides are at different energy states. This is because of the fact that p side has excess holes and n side has excess electrons as free carriers.*




- *The diffusion through the junction start to equalize the number of charge carrier on both sides. As the conduction band of the n side has high density of carrier, electrons of the conduction band diffuse through the junction from the n side to the p side. Similarly holes of the valence band diffuse through the junction from p side to n side.*

- *As more electrons occupy band of p side the fermi level* $E_{FP}$*starts moving upwards along with the entire p-type energy band structure. Similarly more holes entering the valence band of n-side make the fermi level* $E_{Fn}$ *moves downwards. The energy band structure also move downwards with* $E_{Fn}$*. Finally a stage comes when the charge density on both sides of the same band is uniform. In this equilibrium condition the fermi levels* $E_{Fn}$ *and* $E_{Fp}$ *align with each other.*
- *The conduction band and the valence band of both sides are positioned in such a manner that a conduction hill of height* $-eV_0$ *and valence hill of height* $eV_0$ *are formed. These are the potential energies of the electrons and holes respectively due to the potential barrier* $V_0$.

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